

FORM PTO-1390
(REV. 11-2000)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

FUJL 18.096

TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO. (If known, see 37 CFR 1.5

09/763913

INTERNATIONAL APPLICATION NO.
PCT/GB99/03129INTERNATIONAL FILING DATE
21 SEPTEMBER 1999 (21.09.99)PRIORITY DATE CLAIMED
21 SEPTEMBER 1998 (21.09.98)

TITLE OF INVENTION

Interference Reduction in Mobile Stations for CDMA Mobile Communications Networks

APPLICANT(S) FOR DO/EO/US

Sunil Keshavji VADGAMA

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
- a. ☐ is attached hereto (required only if not communicated by the International Bureau).
- b. ☒ has been communicated by the International Bureau.
- c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
- a. ☐ is attached hereto.
- b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
- a. ☐ are attached hereto (required only if not communicated by the International Bureau).
- b. ☐ have been communicated by the International Bureau.
- c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
- d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information: Sub-Power of Attorney

Any fee due with this paper, not fully covered
by an enclosed check, may be charged on
Deposit Acct. No. 08-1634.

Filed by Express Mail
(Receipt No. EL522399535US)
on February 23, 2001
pursuant to 37 C.F.R. 1.10.
by [Signature]

U.S. PATENT AND TRADE OFFICE

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INTERNATIONAL APPLICATION NO
PCT/GB99/03129ATTORNEY'S DOCKET NUMBER
FUJL 18.09621. ☒ The following fees are submitted:**BASIC NATIONAL FEE** (37 CFR 1.492 (a) (1) - (5)):

Neither international preliminary examination fee (37 CFR 1.482)
nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO
and International Search Report not prepared by the EPO or JPO. \$1000.00

International preliminary examination fee (37 CFR 1.482) not paid to
USPTO but International Search Report prepared by the EPO or JPO. \$860.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO
but international search fee (37 CFR 1.445(a)(2)) paid to USPTO. \$710.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO
but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO
and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =**CALCULATIONS PTO USE ONLY**

\$ 860.00

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30
months from the earliest claimed priority date (37 CFR 1.492(e)). \$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$
Total claims	37 - 20 =	17	x \$18.00	\$ 306.00

Independent claims	8 - 3 =	5	x \$80.00	\$ 400.00
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MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$270.00	\$
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TOTAL OF ABOVE CALCULATIONS =

\$ 1,566.00

☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above
are reduced by 1/2. \$

SUBTOTAL =

\$ 1,566.00

Processing fee of \$130.00 for furnishing the English translation later than ☐ 20 ☐ 30
months from the earliest claimed priority date (37 CFR 1.492(f)). \$

TOTAL NATIONAL FEE =

\$ 1,566.00

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be
accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property + \$ 40.00

TOTAL FEES ENCLOSED =

\$ 1,606.00

Amount to be
refunded: \$

charged: \$

- a. ☒ A check in the amount of \$ 1,606.00 to cover the above fees is enclosed.
- b. ☐ Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees.
A duplicate copy of this sheet is enclosed.
- c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any
overpayment to Deposit Account No. 08-1634. A duplicate copy of this sheet is enclosed.
- d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. Credit card
information should not be included on this form. Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR
1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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18,923

REGISTRATION NUMBER

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On : February 23, 2001

By: 

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Attorney Docket No.: HERR 18,096

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor : **Sunil Keshavji VAKGAMA**

Serial No. : **Concurrently Herewith**

Filed : **Concurrently Herewith**

Title : **INTERFERENCE REDUCTION IN MOBILE STATIONS
FOR CDMA MOBILE COMMUNICATIONS
NETWORKS**

February 23, 2001

Assistant Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

SIR :

Prior to the issuance of an Office Action, amend the claims as follows:

IN THE TITLE:

On the line before the title, please add "**TITLE OF THE INVENTION**".

Please change the title to -- INTERFERENCE REDUCTION IN MOBILE
STATIONS FOR CDMA MOBILE COMMUNICATIONS NETWORKS".

Any fee due with this paper, not fully
covered by an enclosed check, may be
charged on Deposit Acct. No. 08-1634

IN THE SPECIFICATION:

Page 1, on the line after the title please add --**BACKGROUND OF THE INVENTION**--.

Page 1, on the line after "**BACKGROUND OF THE INVENTION**", please add -- 1. Field of the Invention --.

Page 1, before line 5, please add -- 2. Description of the Related Art --.

Page 2, after line 15, please add -- **SUMMARY OF THE INVENTION** --.

Page 5, lines 3 and 4, please delete "Reference will now be made, by way of example, to the accompanying drawings, in which:" and add -- **BRIEF DESCRIPTION OF THE DRAWINGS** --.

Page 5, after line 15, please add -- **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS** --.

IN THE CLAIMS:

Please amend the claims as follows on the next page:

WHAT IS CLAIMED IS:

1. (ONCE AMENDED) A mobile station, for use in a CDMA communications network, [including] comprising:

5 a wanted signal processing [means-for] portion which [processing] processes an input signal, representing a CDMA transmission signal received at the mobile station from a base station of the network, to derive therefrom a wanted signal embodying a preselected spreading code;

10 a code information receiving [means-for] portion which [receiving] receives from the base station code information identifying a further spreading code assigned by the network to an interfering signal of another network user; and

15 an interfering signal processing [means-for] portion which [employing] employs the further spreading code identified by the received code information to reduce the interference effect of that interfering signal on the derived wanted signal.

20 2. (ONCE AMENDED) A mobile station as claimed in claim 1, wherein:

25 [the] said code information receiving [means] portion [are] is operable to receive from the base station a plurality of items of code information corresponding respectively to a plurality of such interfering signals, each such item identifying a spreading code assigned by the network to its corresponding interfering signal; and

30 [the] said interfering signal processing [means] portion [are] is operable to employ the spreading codes identified by the received items to reduce the interference effect on the derived wanted signal of each of the interfering signals of [the] said plurality.

35 3. (ONCE AMENDED) A mobile station as claimed in claim 1 [or-2], wherein [the] said input signal of the

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wanted signal processing [means] portion is pre-processed by the interfering signal processing [means] portion to reduce or cancel components in the input signal associated with the or each said interfering signal.

4. (ONCE AMENDED) A mobile station as claimed in claim 3, wherein [the] said interfering signal processing [means] portion [are] is operable to derive, for the or each said interfering signal, a corresponding interference cancellation signal representative of a component in [the] said input signal associated with that interfering signal.

5. (ONCE AMENDED) A mobile station as claimed in claim 4, wherein [the] said interfering signal processing [means] portion [are] is operable to subtract the or each said interference cancellation signal from a signal representing the received CDMA transmission signal to produce [the] said input signal of the wanted signal processing [means] portion.

6. (ONCE AMENDED) A mobile station as claimed in claim 4 [or-5], wherein [the] said interfering signal processing [means] portion [are] is operable to derive the or each said corresponding interference cancellation signal from a signal representing [the] said received CDMA transmission signal.

7. (ONCE AMENDED) A mobile station as claimed in [any one of claims] claim 4 [to-6], wherein [the] said interfering signal processing [means] portion has, for the or each said interfering signal, a corresponding processing unit for deriving [the] said interference cancellation signal corresponding to that interfering signal, which processing unit [includes] comprises:

a code generator [means-for] which [generating] generates the identified spreading code assigned to [the] said interfering signal;

a [despreading means] despreader connected for

receiving a first signal representing the received CDMA transmission signal and also connected to [the] said code generator for receiving the generated spreading code, and operable to despread that signal to produce a
5 second signal representing [the] said interfering signal; and

a [~~respreading means~~] respreader connected to [the] said [~~despreading means~~] despreader for receiving therefrom said second signal and also connected to
10 [the] said code generator [~~means~~] for receiving the generated spreading code, and operable to respread [the] said second signal to produce [the] said corresponding interference cancellation signal.

8. (ONCE AMENDED) A mobile station as claimed in [~~any one of claims~~] claim 4 [to 7], wherein [the] said interfering signal processing [~~means~~] portion further
15 [~~include~~] comprises:

a signal delay [~~means~~] element connected for receiving a basic signal representing [the] said received CDMA transmission signal and operable to delay
20 that basic signal by a preselected delay time to produce a delayed version thereof, [the] said input signal of the or each said processing unit being provided directly by, or being derived from, [the] said
25 basic signal; and

a [~~subtraction means~~] subtractor connected for receiving [the] said delayed version of [the] said basic signal and the or each said interference cancellation signal, and operable to produce [the] said
30 input signal of [the] said wanted signal processing [~~means~~] portion in dependence upon the difference between [the] said delayed version and the or each interference cancellation signal.

9. (ONCE AMENDED) A mobile station as claimed in [~~any preceding~~] claim 1, wherein one or both of [the] said wanted signal processing [~~means~~] portion and [the] said

interfering signal processing [means] portion
comprise(s) a RAKE receiver having a plurality of
fingers for processing different respective paths of
the received CDMA transmission signal.

5 10. (ONCE AMENDED) A mobile station as claimed in
claim 9, wherein each of [the] said wanted signal
processing [means] portion and [the] said interfering
signal processing [means] portion comprises such a RAKE
receiver, and [the] said mobile station further
10 comprises:

a path searcher [means] connected to [the] said
wanted signal processing [means] portion and to [the]
said interfering signal processing [means] portion for
supplying the same path information thereto; and

15 a path information delay [means] element connected
between [the] said path searcher [means] and [the] said
wanted signal processing [means] portion for delaying
supply of the path information to the wanted signal
processing [means] portion for a preselected delay time
20 after the same path information is supplied to [the]
said interfering signal processing [means] portion.

11. (ONCE AMENDED) A mobile station as claimed in [any
preceding] claim 1, wherein [the] said code information
receiving [means] portion [are] is operable to receive
25 [the] said code information via a common control
channel broadcast by the base station to all mobile
stations in its area.

12. (ONCE AMENDED) A mobile station as claimed in [any
~~one of claims~~ claim 1 [to ~~10~~], wherein [the] said code
information receiving [means] portion [are] is operable
30 to receive [the] said code information via a control
channel associated individually with the mobile
station.

13. (ONCE AMENDED) A mobile station as claimed in [any
preceding] claim 1, wherein [the] said base station is
35 operable to form respective beams for directing its

CDMA transmission signals towards their respective users and is also operable to transmit to [the] said mobile station interference judgement information providing, for each of a plurality of users operating in its area, information relevant to assessing an interference effect on the wanted signal of [the] said mobile station of an interfering signal of the user concerned;

[the] said mobile station comprising:

an interfering signal assessment [~~means for~~ portion which assessing [the] said interference effect of the interfering signal of each user of [the] said plurality based on the received interference judgement information; and

an interfering signal selection [~~means for~~ portion which selecting one or more of the interfering signals from amongst the respective interfering signals of the users of [the] said plurality based on the results of the assessment.

14. (ONCE AMENDED) A mobile station as claimed in claim 13, wherein [the] said interference judgement information for such a user of [the] said plurality includes position information of that user.

15. (ONCE AMENDED) A mobile station as claimed in claim 13 [~~or 14~~], wherein [the] said interference judgement information for such a user of [the] said plurality includes angular position information of the user relative to the base station.

16. (ONCE AMENDED) A mobile station as claimed in [~~any one of claims~~ claim 13 [~~to 15~~], wherein [the] said interference judgement information for such a user of [the] said plurality includes downlink transmission power level information of that user.

17. (ONCE AMENDED) A mobile station as claimed in [~~any one of claims~~ claim 13 [~~to 16~~], wherein [the] said interfering signal assessment [~~means~~ portion take

account of the position of each user of [the] said plurality relative to the position of the mobile station in assessing [the] said interference effect.

18. (ONCE AMENDED) A mobile station as claimed in [any one of claims] claim 13 [to 17], wherein [the] said interfering signal assessment [means] portion include storage [means for] which storing the received interference judgement information for each user of [the] said plurality.

19. (ONCE AMENDED) A mobile station as claimed in [any one of claims] claim 13 [to 18], wherein the users of [the] said plurality are users whose downlink transmission rates exceed a predetermined threshold value.

20. (ONCE AMENDED) A base station, for use in a CDMA communications network, [including] comprising:
an interfering signal designating [means for] portion which [designating] designates at least one of a plurality of downlink signals transmitted by the base station as being an interfering signal having an interference effect on a wanted signal of a subject mobile station of the network; and

a code information transmission [means for] portion which [including] includes, in a predetermined control signal transmitted by the base station to [the] said subject mobile station, code information, identifying a spreading code assigned by the network to the designated interfering signal, for use by the subject mobile station to reduce [the] said interference effect of [the] said interfering signal on its said wanted signal.

21. (ONCE AMENDED) A base station as claimed in claim 20, wherein [the] said predetermined control signal is broadcast by the base station to all mobile stations in its area using a common control channel.

22. (ONCE AMENDED) A base station as claimed in claim

20, wherein [the] said predetermined control signal is transmitted by the base station to [the] said subject mobile station using a control channel associated individually with that mobile station.

23. (ONCE AMENDED) A base station as claimed in [any one of claims] claim 20 [to 22], further comprising:

an interfering signal assessment [means for] portion which [assessing] assesses, for each of a plurality of users operating in the area of the base station, [the] said interference effect on [the] said wanted signal of [the] said subject mobile station of the downlink signal of the user concerned; [the] said interfering signal [designation means] designating portion being operable to determine which downlink signals of the users of [the] said plurality are to be designated as such interfering signals based on the results of the assessment.

24. (ONCE AMENDED) A base station as claimed in claim 23, wherein [the] said interfering signal assessment [means] portion [are] is operable to assess [the] said interference effect in dependence upon the bit rate of the downlink signal.

25. (ONCE AMENDED) A base station as claimed in [any one of claims] claim 20 [to 24], wherein [the] said base station further [includes] comprises [beamforming means for] a beamformer which [forming] forms respective beams for directing its CDMA transmission signals towards their respective users.

26. (ONCE AMENDED) A base station as claimed in claim 25, wherein [the] said interfering signal assessment [means] portion [are] is operable to assess [the] said interfering effect in dependence upon a position of the user relative to [the] said subject mobile station.

27. (ONCE AMENDED) A base station as claimed in claim 25 [or 26], wherein [the] said interfering signal assessment [means] portion [are] is operable to assess

[the] said interference effect in dependence upon one or more of the following criteria:

an angular position of the user relative to [the] said base station;

5 an angular position of [the] said subject mobile station relative to the base station;

a distance of the user from the base station;

a distance of the subject mobile station from the base station;

10 a downlink transmission power level of the user; and

a downlink-signal bit-rate of the user.

28. (ONCE AMENDED) A base station as claimed in claim 20 [~~, 21 or 22~~], further [including] comprising:

15 [~~beamforming means for~~] a beamformer which [forming] forms respective beams for directing its CDMA transmission signals towards their respective users;

an interference judgement information transmission [~~means for~~] portion which [including] includes, in a
20 predetermined control signal transmitted by the base station to [the] said subject mobile station, interference judgement information providing, for each of a plurality of users operating in the area of the base station, information relevant to assessing an
25 interference effect on [the] said wanted signal of the downlink signal of the user concerned.

29. (ONCE AMENDED) A base station as claimed in claim 28, wherein [the] said interference judgement information for such a user of [the] said plurality
30 includes position information of that user.

30. (ONCE AMENDED) A base station as claimed in claim 28 [~~or 29~~], wherein [the] said interference judgement information for such a user of [the] said plurality includes angular position information of the user
35 relative to the base station.

31. (ONCE AMENDED) A base station as claimed in [any

one of claims] claim 28 [to 30], wherein [the] said interference judgement information for such a user of [the] said plurality includes downlink transmission power level information of that user.

5 32. (ONCE AMENDED) A CDMA communications network [including] comprising:

a mobile station; and

a base station operable to designate at least one of a plurality of downlink signals transmitted thereby as being an interfering signal having an interference effect on a wanted signal of [the] said mobile station, and also operable to include, in a predetermined control signal transmitted thereby to [the] said mobile station, code information identifying a spreading code assigned by the network to the designated interfering signal;

the mobile station being operable to receive [the] said predetermined control signal and to employ [the] said spreading code identified by the code information included in that signal to reduce [the] said interference effect of that interfering signal on [the] said wanted signal.

33. (ONCE AMENDED) A receiving method, for use in a mobile station of a CDMA communications network, [including] comprising ~~[the steps of]~~:

receiving a CDMA transmission signal from a base station of the network;

processing an input signal representing the received CDMA transmission signal to derive therefrom a wanted signal embodying a preselected spreading code;

receiving from the base station code information identifying a further spreading code assigned by the network to an interfering signal of another network user; and

employing the further spreading code identified by the received code information to reduce the

interference effect of that interfering signal on the derived wanted signal.

34. (ONCE AMENDED) A transmission method, for use in a base station of a CDMA communications network,

5 [including] comprising ~~[the steps of]~~:

designating at least one of a plurality of downlink signals transmitted by the base station as being an interfering signal having an interference effect on a wanted signal of a subject mobile station
10 of the network; and

including, in a predetermined control signal transmitted by the base station to the subject mobile station, code information, identifying a spreading code assigned by the network to the designated interfering
15 signal, for use by the mobile station to reduce [the] said interference effect of [the] said interfering signal on its said wanted signal.

35. (ONCE AMENDED) A CDMA communications method, [including] comprising ~~[the steps of]~~:

20 designating at least one of a plurality of downlink signals transmitted by a base station of the network as being an interfering signal having an interference effect on a wanted signal of a subject mobile station of the network;

25 including, in a predetermined control signal transmitted by the base station to the subject mobile station, code information identifying a spreading code assigned by the network to the designated interfering signal;

30 receiving the predetermined control signal at the mobile station and employing the spreading code identified by the code information included in that signal to reduce the interference effect on the wanted signal of that interfering signal.

36. (NEW) A mobile station, for use in a CDMA communications network, comprising:

wanted signal processing means for processing an input signal, representing a CDMA transmission signal received at the mobile station from a base station of the network, to derive therefrom a wanted signal
5 embodying a preselected spreading code;

code information receiving means for receiving from the base station code information identifying a further spreading code assigned by the network to an interfering signal of another network user; and

10 interfering signal processing means for employing the further spreading code identified by the received code information to reduce the interference effect of that interfering signal on the derived wanted signal.

37. (NEW) A base station, for use in a CDMA
15 communications network, comprising:

interfering signal designating means for designating at least one of a plurality of downlink signals transmitted by the base station as being an interfering signal having an interference effect on a
20 wanted signal of a subject mobile station of the network; and

code information transmission means for including, in a predetermined control signal transmitted by the base station to said subject mobile station, code
25 information, identifying a spreading code assigned by the network to the designated interfering signal, for use by the subject mobile station to reduce said interference effect of said interfering signal on its said wanted signal.

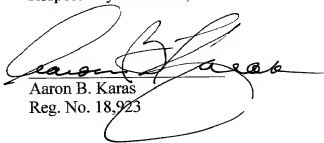
IN THE ABSTRACT:

Page 36, line 1, please change "ABSTRACT" to -- ABSTRACT OF THE
DISCLOSURE--.

REMARKS

Any fee due with this paper, not fully covered by an enclosed check, may be charged
on Deposit Account 08-1634.

Respectfully submitted,



Aaron B. Karas
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INTERFERENCE REDUCTION IN MOBILE STATIONS FOR CDMA MOBILE COMMUNICATIONS NETWORKS

The present invention relates to code-division multiple access (CDMA) mobile communications networks.

5 In a CDMA mobile communications network, multi-user interference reduces the bit error rate (BER) performance of the radio link and as a result reduces the network capacity. Such performance degradation is exacerbated by imperfect power control and high-rate data users. In the proposed wideband CDMA (W-CDMA) 10 element of the standard referred to as UMTS/IMT2000 the multi-user interference caused by high-rate data users to low-rate service users is expected to be significant. UMTS relates to the Universal Mobile Telecommunications System standard of the European Telecommunications Standards Institute (ETSI) and IMT2000 relates to the International Mobile Telecommunications 2000 standard of the International Telecommunications Union (ITU-R) TGS/1.

20 Incidentally, in the proposed W-CDMA standard, a high data rate would be 384kbit/s or 2Mbit/s, for example. In comparison, a digitised voice signal typically has a low bit rate of, say, 20kbit/s.

25 Heretofore, many multi-user interference cancellation techniques have been proposed with a view to reducing and potentially eliminating the performance degradation caused by multi-user interference. However, in practice the complexity of such previously-proposed techniques makes them only suitable for 30 implementation in base stations of a CDMA network. This, however, only enables the performance degradation caused by multi-user interference in the uplink direction (from the mobile stations to the base station) to be addressed.

35 In UMTS/IMT2000 it is recognised that many services will demand an asymmetric capacity with

relatively high bit rates in the downlink direction and relatively low bit rates in the uplink direction, for example Internet web-browsing. For such services having a high bit rate in the downlink direction, multi-user interference cancellation techniques implemented in the base stations are of relatively little value as the uplink-direction bit rates are low.

It is therefore desirable to provide a low-complexity multi-user interference cancellation technique suitable for implementation in a mobile station of the network. Such a technique can increase the effective network capacity in the downlink direction, particularly when the network is providing services to high-rate data users in the downlink direction.

According to a first aspect of the present invention there is provided a mobile station, for use in a CDMA communications network, including: wanted signal processing means for processing an input signal, representing a CDMA transmission signal received at the mobile station from a base station of the network, to derive therefrom a wanted signal embodying a preselected spreading code; code information receiving means for receiving from the base station code information identifying a further spreading code assigned by the network to an interfering signal of another network user; and interfering signal processing means for employing the further spreading code identified by the received code information to reduce the interference effect of that interfering signal on the derived wanted signal.

According to a second aspect of the present invention there is provided a base station, for use in a CDMA communications network, including: interfering signal designating means for designating at least one of a plurality of downlink signals transmitted by the

base station as being an interfering signal having an interference effect on a wanted signal of a subject mobile station of the network; and code information transmission means for including, in a predetermined control signal transmitted by the base station to the said subject mobile station, code information, identifying a spreading code assigned by the network to the designated interfering signal, for use by the subject mobile station to reduce the said interference effect of the said interfering signal on its said wanted signal.

According to a third aspect of the present invention there is provided a CDMA communications network including: a mobile station; and a base station operable to designate at least one of a plurality of downlink signals transmitted thereby as being an interfering signal having an interference effect on a wanted signal of the said mobile station, and also operable to include, in a predetermined control signal transmitted thereby to the said mobile station, code information identifying a spreading code assigned by the network to the designated interfering signal; the mobile station being operable to receive the said predetermined control signal and to employ the said spreading code identified by the code information included in that signal to reduce the said interference effect of that interfering signal on the said wanted signal.

According to a fourth aspect of the present invention there is provided a receiving method, for use in a mobile station of a CDMA communications network, including the steps of: receiving a CDMA transmission signal from a base station of the network; processing an input signal representing the received CDMA transmission signal to derive therefrom a wanted signal embodying a preselected spreading code; receiving from

the base station code information identifying a further spreading code assigned by the network to an interfering signal of another network user; and employing the further spreading code identified by the received code information to reduce the interference effect of that interfering signal on the derived wanted signal.

According to a fifth aspect of the present invention there is provided a transmission method, for use in a base station of a CDMA communications network, including the steps of: designating at least one of a plurality of downlink signals transmitted by the base station as being an interfering signal having an interference effect on a wanted signal of a subject mobile station of the network; and including, in a predetermined control signal transmitted by the base station to the subject mobile station, code information, identifying a spreading code assigned by the network to the designated interfering signal, for use by the mobile station to reduce the said interference effect of the said interfering signal on its said wanted signal.

According to a sixth aspect of the present invention there is provided a CDMA communications method, including the steps of: designating at least one of a plurality of downlink signals transmitted by a base station of the network as being an interfering signal having an interference effect on a wanted signal of a subject mobile station of the network; including, in a predetermined control signal transmitted by the base station to the subject mobile station, code information identifying a spreading code assigned by the network to the designated interfering signal; receiving the predetermined control signal at the mobile station and employing the spreading code identified by the code information included in that

signal to reduce the interference effect on the wanted signal of that interfering signal.

Reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 shows parts of receiving circuitry in a mobile station embodying the present invention;

Figure 2 shows parts of transmitting circuitry in a base station embodying the present invention;
Figure 3 shows a schematic view of a cell area of a cellular communications network;

Figure 4 shows possible formats of messages for transmission from a base station to a mobile station in an embodiment of the present invention; and

Figure 5 shows parts of interferer assessment circuitry in an embodiment of the present invention.

As is well known, in a direct-spreading (DS) CDMA communications network, each channel between a transmitter and a receiver is assigned a predetermined pseudo-random binary sequence (or code) that modulates the carrier of the transmission signal, spreading the spectrum of the transmission-signal waveform. A large number of CDMA signals can share the same frequency spectrum. At the receiver, the CDMA transmission signals are separated by using a correlator which ideally accepts only signal energy of the channel (the "wanted channel") embodying the assigned binary sequence or code and despreads its spectrum. The CDMA transmission signals of other users (the "unwanted channels"), whose codes do not match, are not despread in bandwidth and, as a result, contribute only to the noise and represent a self-interference generated by the network. This self-interference is exacerbated by multipath propagation which increases the cross-correlation between the spreading codes of different users, leading to an increased multi-user interference. One result of the increased cross-correlation between

the codes is that the signals of other users "leak" through the correlator, degrading the BER performance of the wanted signal.

Accordingly, in a CDMA mobile communications network, each downlink channel from a base station to a mobile station is allocated a spreading code, or possibly a combination of spreading codes. For example, one preferred implementation uses a combination of two spreading codes: a so-called long spreading code and a so-called short spreading code. In the latter case, generally each base station employs the same long spreading code for all of its downlink channels.

Generally, high bit-rate channels either make use of multi-code transmission or use a low spread factor (i.e. a low number of chips per symbol). In the case of a low spread factor, for example a factor of 16, because each symbol is composed of fewer chips, in order to maintain sufficient energy per bit at the edge of a cell, a higher transmission power is needed. This higher transmission power results in greater multi-user interference to other users within the cell.

To deal with the problem of multi-user interference in the downlink direction, a base station embodying the present invention broadcasts, using either a channel common to all users (a "common control channel" or "common broadcast channel") or a control channel associated individually with each particular traffic channel (an "associated control channel" or ACCH), code information identifying the spreading code (or each spreading code if multi-code spreading is being used) allocated to at least one downlink channel (the "interfering channel") considered to be carrying a significant interfering signal, e.g. high bit-rate traffic or employing a relatively high transmit power to reach a user who is in a shadow fade, in a building

or simply at the edge of the cell. A mobile station embodying the present invention receives the broadcast information from the base station identifying the or each code allocated to the interfering channel(s). As
5 all of the downlink channels received at a particular mobile station from the local base station are subject to the same channel distortion, both the wanted and unwanted user channels suffer the same propagation distortion so a channel estimate valid for the wanted
10 user channel will also be valid for the or each interfering channel. Thus, no separate channel estimate is required for these interfering channels. Furthermore, all of the channels received at the mobile station from a single base station (or from a single
15 sector of a base station) are synchronous and all the channels suffer the same multi-path dispersion. Accordingly, given the code information supplied by the base station identifying the or each code used by the interfering channel(s), the mobile station can select
20 and process the received signals of the interfering channel(s) in such a way as to remove or reduce their interference effect on the received signal of the wanted channel.

By way of example, one embodiment of a mobile
25 station according to the invention will now be described with reference to Figure 1.

In Figure 1, receiving circuitry 10 of the mobile station includes a wanted signal processing section 12, an interfering signal processing section 14, and a path
30 searcher 16.

The wanted signal processing section 12 is in the form of a RAKE receiver having n fingers. In a multi-path environment, multiple versions of the wanted transmission signal sent from the base station will be
35 received at the mobile station. The path searcher 16 in the receiving circuitry processes the signal RX

received at the mobile station to identify the n best versions (or paths) of the wanted transmission signal in the received signal RX. Then, each of these n paths is processed individually by a different one of the n fingers in the wanted signal processing section 12.

Each finger of the wanted signal processing section 12 comprises a correlator 22, a channel estimator 24 and a complex-conjugate multiplier 26. The correlator 22 receives a processed version PRX of the received signal RX and despreads (or correlates and integrates over one symbol period) that signal in accordance with a spreading code SC_W assigned to the wanted signal to produce a despread signal DPRX representing the wanted signal. This spreading code SC_W is supplied to the correlator 22 in each finger by a code generator 28. The code generator 28 is connected, via a delay element 18, to the path searcher 16 for receiving therefrom path information PI identifying the n best paths.

In each finger the channel estimator 24 receives the resulting despread signal DPRX from the correlator 22 in its finger and derives therefrom a channel estimate CE for its particular path of the wanted signal. This channel estimate is combined with the despread signal DPRX in the complex-conjugate multiplier 26 to produce a finger output signal FOS for the finger concerned.

The respective finger output signals FOS_1 to FOS_n of the n fingers are supplied to a combiner 30 which combines the signals to produce a combined output signal COS representing the wanted signal.

A decision circuit 32 receives the combined output signal COS and, employing a soft-decision process or a hard-decision process, derives from the COS signal a sequence RXSYMBOL of symbols embodied in the wanted signal. This sequence of symbols is applied to a

demultiplexer 34 which separates the symbols of the sequence into symbols belonging to a traffic channel TCH of the wanted signal and symbols belonging to an associated control channel ACCH of the wanted signal. The symbols belonging to the TCH and ACCH are output separately from the receiving circuitry 10 to further circuitry of the mobile station.

The interfering signal processing section 14 also comprises a plurality m of processing units PU corresponding respectively to m different interfering signals which the interfering signal processing section 14 is to process. m is, for example, less than or equal to 10; 6 is presently contemplated.

Each processing unit PU is in the form of a RAKE receiver and comprises n_i fingers, each comprising a correlator 42, a delay element 43 and a resreader 44. The number n_i of fingers in a processing unit PU need not be the same as the number n of fingers in the wanted signal processing section 12. Generally, n_i will be less than or equal to n . By making $n_i < n$, the complexity of the interfering signal processing section can be reduced. In this case, for example, only the n_i paths above a certain power level threshold are chosen for processing in the processing unit. If desired, n_i can even be varied between the different processing units PU. For example, a first one, or a first set of, the processing units could have a higher n_i than the remaining processing units; such higher- n_i PUs have a better potential interfering-signal processing effect but will cost more and consume more power.

Each processing unit PU further comprises a code generator 46 which supplies the correlator 42 in each of the n_i fingers of its processing unit PU with a spreading code SC_i of its corresponding interfering signal. The correlator 42 also receives the received signal RX and despreads it to produce a despread

interference signal DIS representing its corresponding interfering signal. The interfering signal DIS is applied to the resreader 44 in the finger which also receives the spreading code SC_i allocated to the interfering signal being processed. The resreader 44 re-spreads the DIS signal of its finger using the allocated spreading code SC_i (delayed by the delay element 43) to produce a finger respread signal FRS for its particular finger.

The respective finger respread signals of the n fingers in all m processing units PU are applied to respective negative inputs of a summing element 48 (only one such negative input is shown in Figure 1 for the sake of simplicity). The received signal RX is also applied to a delay element 50 which produces a delayed version RXD of the received signal. This delayed signal RXD is applied to a positive input of the summing element 48. The above-mentioned processed version PRX of the received signal is produced at the output of the summing element 48 based on the difference between the RXD signal and the sum of all of the finger respread signals FRS produced by the interfering signal processing section 14.

The interfering signal processing section 14 further comprises a code identity derivation portion 52 which is connected to the output of the demultiplexer 34 for receiving the symbol sequence of the ACCH in the wanted channel. The code identity derivation portion 52 derives from the ACCH symbol sequence respective items of code information CI_{i1} to CI_{im} for the m interfering signals which the interfering signal processing section 14 is to process. These items of code information are applied respectively to the code generators 46 in the m processing units PU. The code generator 46 in each processing unit PU derives the spreading code SC_i for application to the correlator 42

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and respreader 44 in each of its n fingers from the received code information CI_i . The code generators 46 are also connected to the path searcher 16 for receiving therefrom the above-mentioned path information PI.

Operation of the Figure 1 circuitry will now be described. As described later in more detail, a base station of the cell in which the mobile station is operating periodically transmits, using the ACCH in this embodiment, the m items of code information CI_{i1} to CI_{im} of the m high-bit-rate interfering signals which the mobile station is to process.

The receiving circuitry 10 in the mobile station processes the received signal RX to extract the symbol sequence RXSYMBOL of the wanted channel and derives therefrom the ACCH symbol sequence which is delivered to the input of the code identity derivation section 52. The code identity derivation section 52 detects the m items of code information CI in the ACCH symbol sequence and delivers the m items to the m processing units PU respectively of the interfering signal processing section 14. The items of code information may be, for example, mapping information in accordance with a conventional form of code-mapping (e.g. in one form of code-mapping a so-called "code tree" is used for generating orthogonal variable spreading factor (OVSF) codes). This is convenient, since conventional code generators are available that are adapted to receive such code-mapping information and to derive the corresponding spreading codes SC from the mapping information. The code identities are generally shorter than the codes to which they correspond, so that bandwidth is also saved. If desired, however, the spreading codes SC themselves may be sent to the mobile station instead of the code identities.

In each symbol period of the transmission signal

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the path searcher 16 operates to identify the n best paths between the base station and the mobile station. Averaging over more than one symbol period may be applied to enhance the path-searcher performance. As indicated previously, because the channels from a single base station or a single sector of a base station are synchronous and because all the channels suffer the same multi-path dispersion, the best n paths identified by the path searcher 16 for the wanted signal are also the n best paths for the interfering signals. Accordingly, the path information PI identifying the n best paths is supplied in common to the code generator 28 in the wanted signal processing section 12 and to the respective code generators 46 in the m processing units PU of the interfering signal processing section 14.

The path information PI is supplied to the wanted signal processing section 12 via the delay element 18 so that, in each symbol period, the path information reaches the code generator 28 a preselected delay time after it reaches the code generators 46 in the interfering signal processing section 14. This delay is required because of the latency associated with the signal processing performed in the processing units PU. The preselected delay time is chosen such that the delayed path information applied to the code generator 28 is in phase with the processed version PRX of the received signal applied to the input of the wanted signal processing section 12.

In each processing unit PU the n_i fingers then despread the received signal RX using the spreading code SCI of the interfering signal corresponding to that processing unit. The correlator 42 in each finger ideally accepts only signal energy of the interfering signal corresponding to the processing unit PU concerned and despreads its spectrum to reproduce the

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interfering signal DIS concerned. The delay element 43 delays the application of the spreading code SC_i to the respreader 44, after its application to the despreader 42, by a delay time corresponding to a propagation delay of the despreader 42. The despread signal DIS is then respread by the respreader 44 in the finger concerned to produce the finger respread signal FRS representing the interfering signal of one of the n_i paths.

The processing units PU operate in parallel, with each of them processing a different corresponding one of the interfering signals. The n_i FRS signals produced by each processing unit PU are subtracted from the delayed version RXD of the received signal by the summing element 48 to produce the processed version PRX of the received signal for application to the wanted signal processing section 12. The signal processing in the processing units PU inevitably introduces some delay in the signal processing paths between the receive signal RX and the negative inputs of the summing element 48. The delay produced by the delay element 50 is chosen such that the delayed version RXD of the received signal arrives at the positive input of the summing element 48 in phase with the respread interfering signals FRS.

In the summing element 48 each of the n_i paths of each of the m interfering signals is subtracted from the delayed version RXD of the received signal. In this way, the m interfering signals whose spreading codes were identified to the mobile station can be subtracted or cancelled out from the received signal RX.

The resulting interference-cancelled signal PRX is processed by the wanted signal processing section 12 in the usual manner. Using the path information PI provided by the path searcher 16 and the code SC_w

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allocated to the wanted signal each finger despreads the wanted signal of one of the n paths identified by the path searcher 16. The channel estimator 24 processes the despread signal DPRX for the path concerned, using for example pilot symbols included in the transmission signal by the base station. The resulting channel estimate CE provides an estimate of the propagation conditions along the path concerned (e.g. delay and fading). The channel estimate CE for the path is then multiplied with the despread signal DPRX in the complex-conjugate multiplier 26 to produce the output signal FOS for that finger.

The n FOS signals are then combined in the combiner 30 to produce the COS signal. The COS signal is demodulated in the decision element 32 to produce the received symbol sequence RXSYMBOL. Symbols belonging to the traffic channel TCH are delivered by the demultiplexer 34 to one output thereof whilst symbols belonging to the associated control channel ACCH are delivered to the other output thereof and to the code identity derivation section 52.

Figure 2 shows parts of transmitting circuitry included in a base station for transmitting the items of code information CI to the mobile station of Figure 1.

In this embodiment, it is assumed that the transmission signals employ both short and long codes, and that the long code is the same for all downlink channels of the base station concerned.

In Figure 2 it is also assumed that there are r normal channels carrying low-or medium-bit rate data, for example voice data. Each of these normal channels has a traffic channel TCH and an associated control channel ACCH. It is also assumed that there are m high bit-rate users (HBRUs), each having a high bit-rate data (HBRD) channel and an associated control channel

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ACCH.

The transmitting circuitry 100 at the base station comprises a code allocation unit 102, respective HBRU code identifier insertion units 104_1 to 104_{r+m+1} , respective spreaders 106_1 to 106_{r+m+1} , a short code generator 108, a combiner 110, a further spreader 112, and a long code generator 114.

The code allocation unit 102 receives code allocation commands from further circuitry of the base station and allocates each of the r normal channels and each of the m HBRD channels a particular short code for use in the downlink direction. The code allocation unit 102 produces respective items of code information CI_1 to CI_r for the r normal channels and respective items of code information CI_{r+1} to CI_{r+m+1} for the m HBRD channels.

The items of code information are, for example, code-mapping information items, as mentioned previously.

The items of code information CI_{r+1} to CI_{r+m+1} for the HBRD channels are supplied to all of the HBRU code identifier insertion units 104_1 to 104_{r+m+1} . These units periodically (e.g. once in every 10ms frame) include the m items of HBRU code information CI_{r+1} to CI_{r+m+1} in the symbol sequence of the associated control channels ACCH of all users (low/medium bit rate users and high bit rate users). The presence of the items of code information in the ACCH concerned may be denoted by a predetermined header or a predetermined flag in the symbol sequence.

For each user, the symbol sequence of the TCH (or HBRD as the case may be) is combined with the symbol sequence of the ACCH by the HBRU code identifier insertion portion and the resulting combined sequence is applied to one input of the spreader 106 of the channel concerned. The spreader 106 for each channel

also receives the short spreading code SC allocated to the channel which is generated by the short code generator 108. The short code generator 108 receives the items of code information CI_1 to CI_{r+m+1} for all
5 users and, using the ETSI mapping, produces the appropriate short codes SC_1 to SC_{r+m+1} allocated to the users by the code allocation unit 102.

The spreader 106 for each channel spreads the combined TCH/ACCH (or HBRD/ACCH) symbol sequence using
10 the short spreading code SC for its channel and delivers a spread signal S to an input of the combiner 110. The combiner 110 combines all of the spread signals S_1 to S_{r+m+1} to produce a combined spread signal. The combined spread signal CS is spread again
15 in accordance with a long code LC applied to the further spreader 110 by the long code generator 114 to produce an output signal OS for transmission to the mobile station.

It will be appreciated that in the Figure 2
20 embodiment the m items of code information CI_{r+1} to CI_{r+m+1} are inserted in the ACCH of each HBRU. However, in the mobile station of such an HBRU, the interfering signal processing section 14 must not treat its own wanted signal as one of the interfering
25 signals. To avoid this happening, the transmitting circuitry 100 in the base station may be adapted to omit the HBRU's own item of code information CI from the set of items of code information included in its ACCH. Alternatively, the code identity derivation
30 section 52 in the mobile station may be adapted to compare each item of code information CI received thereby in its ACCH with the code information allocated to the user concerned to avoid passing the user's own item of code information item to the interfering signal
35 processing section 14.

A further embodiment of the present invention will

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now be explained with reference to Figures 3 to 5.

Figure 3 shows schematically the area of one cell of a CDMA mobile communication system. In this embodiment, a base station BS of the cell utilises beamforming adaptive array antennae for transmitting downlink signals to the mobile stations operating in the cell area. The purpose of such beamforming adaptive array antennae is to direct the downlink signal for a particular user to the current location of the user within the cell area, rather than transmitting it uniformly across the cell area. In this way, the interference caused to other users is reduced and so, in theory, the maximum number of users that can be supported per cell can be increased.

By way of example, Figure 3 shows a situation in which two high bit-rate users HBRU1 and HBRU2 are operating within the cell area of the base station BS. A first beam B1 is formed in a first direction by the base station for downlink communication with the user HBRU1. A second beam B2 is formed in a second direction, different from the first direction, by the base station for downlink communication with the user HBR2.

A mobile station MS of a further, low- or medium-bit-rate user is also operating in the cell area, and the base station BS communicates with the MS using a third beam B3.

As shown in Figure 3, the angular position of the MS is different from the angular position of the user HBRU1 but is approximately the same as the angular position of the user HBRU2. This means that the amount of interference caused to the MS by the user HBRU1 is low (negligible), whereas that caused by the user HBRU2 is highly significant.

Bearing in mind that in practice the number of potentially-interfering high-bit-rate users in any

particular cell may exceed the number m of interfering signals which a mobile station can process, it is desirable to take account of the positions (relative to the subject mobile station), and/or other factors such as downlink transmission power, of the potentially-interfering users to select the interfering signals that are to be cancelled by the subject mobile station.

In this case, as in the first embodiment described with reference to Figures 1 and 2, the base station supplies information to each mobile station operating within its cell area to identify directly, or to facilitate identification at the mobile station of, the interfering users relevant to that particular mobile station.

In a first possible implementation, shown in Figure 4, the base station broadcasts two different types of message to all the mobile stations in its cell area using a common broadcast channel (CBCH).

The first type of message, called an ID message, commences with a first type of header (HDR A), enabling the message type to be identified at the receiving mobile station. After the header, the next field in the ID message is an interferer number field, containing an integer from 1 to x , where x is the number of candidate interfering signals handled by the base station ($x > m$, where m is the number of processing units PU in the interfering signal processing section 14). The next field of the ID message contains the item of code information CI_1 assigned to the interfering user having the interferer number specified in the preceding field. The final two fields of the ID message contain respectively an initial angular position and an initial downlink transmission power of the interfering user specified in the interferer number field.

Such an ID message is transmitted, for example,

whenever a new candidate interfering signal (e.g. HBRU) becomes active within the cell area.

The other type of message broadcast by the base station to the mobile stations in its cell area is an update message which has a second header (HDR B) different from the first header (HDR A). As for the ID message, the first field in the update message following the header is an interferer number field which, as before, is used to identify the candidate interfering user to which the message relates. The final two fields of the update message are, respectively, an angular position update field and a downlink transmission power update field. These update fields either contain directly the latest angular position and downlink transmission power of the user concerned or, alternatively, information for combination with the initial angular position and downlink transmission power specified in an ID message relating to the user concerned to enable the mobile station itself to determine the latest angular position and downlink transmission power of the user concerned. In the latter case, for example, the information contained in the update field could simply be the change in angular position or downlink transmission power since the original ID message or the last update message for the user concerned. Assuming that such changes are small, this enables the length of the update message to be reduced as compared to that of an original ID message.

The update messages are transmitted for example at regular intervals, for example every 10ms frame.

Figure 5 shows a block diagram of parts of interferer assessment circuitry 152 which can be used to process the ID messages and update messages broadcast via the CBCH of Figure 4. This interferer assessment circuitry 152 takes the place of the code

identity derivation portion 52 shown in Figure 1. However, because in this embodiment the code information and interference judgement information (ID and update messages) are broadcast via the CBCH, a
5 separate receiver circuit (not shown) is required (in addition to the wanted signal processing section 12 in section 12 in Figure 1) to process the information sent via the CBCH.

Because a separate receiver is used to process the
10 CBCH, it is possible for the CBCH to be one of the interfering signals selected for cancelling in the mobile station, if it is found that the CBCH is a significant interfering signal.

The interferer assessment circuitry 152 comprises
15 an interferer control portion 162 and an interferer information storage portion 164.

The interferer information storage portion 164 is
20 in the form of a table having entries from 1 to x corresponding respectively to the x candidate interfering users notified by the base station. Each entry has respective short code ID, angular position, and downlink transmission power fields for the candidate interfering user concerned.

When an ID or update message is received at the
25 mobile station via the CBCH, the interferer control portion 162 processes the message to determine its type (ID or update). If the message is an ID message (HDR A) the short code ID, initial angular position and initial downlink transmission power contained in the
30 message are stored in the appropriate entry for the candidate interfering user in the interferer information storage portion 164. If the message is an update message (HDR B) the interferer control portion 162 uses the angular position update and downlink
35 transmission power update information contained in the message to update the angular position and transmission

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power field of the entry in the interferer information storage portion 164 for the candidate interfering user concerned.

Periodically, for example every 10ms frame, or each time a new ID or update message is received, the interferer control portion 162 processes the information in the interferer information storage portion 164 to assess what interference effect each candidate interfering user in the table is likely to have at its mobile station. The assessment is made based on a comparison of the angular position of its mobile station (notified to it periodically by the base station) with the latest angular position of each candidate interfering user as maintained in the angular position field of the table. The assessment process also takes into account the downlink transmission powers of the candidate interferers. Those with higher downlink transmission powers (in particular those at the periphery of the cell area) are likely to be more significant interferers than those with low transmission powers.

Based on the results of the assessment of the likely interference effects of the different candidate interfering users, the interferer control portion 162 then selects the m interfering users most likely to be significant to its mobile station and supplies the respective items of code information CI_{i1} to CI_{im} for those m users (as stored in the storage portion 164) to the processing units PU in the interfering signal processing section (14 in Figure 1).

Although as described above the base station transmits the downlink transmission power of the candidate interferers to the mobile station, it would be possible instead to transmit some measure of the distance between the base station and the interfering user concerned. Also, it is not necessary that both

angular position and downlink transmission power be taken into account. Either of these two types of information alone could be transmitted and used to select the most significant interferers.

5 It is also not necessary for the information to be broadcast on the CBCH in the particular format shown in Figure 4. A large variety of different formats could be used. Instead of individual messages for the different candidate interferers, the information could
10 be sent in blocks containing in a predetermined order the information for all the candidate interferers.

The actual data rates of the candidate interferers (e.g. HBRUs) could also be broadcast to the mobile station to enable them to take account of these in
15 selecting the most significant interferers. For example, an HBRU with a very high rate, even if spaced significantly far away from the subject mobile station, might still be a more significant interferer than another HBRU having a lower data rate but much closer
20 to the subject mobile station.

In the above example, the selection of the likely significant interfering users is made by the mobile station based on broadcast information from the base station. This requires the mobile station to have
25 relatively complex circuitry for processing the broadcast messages from the base station, which may be undesirable from the point of view of cost.

It is alternatively possible for the selection of the likely significant interferers for each mobile
30 station to be made individually for each mobile station by the base station, thereby avoiding complex assessment and selection circuitry in the mobile station. The base station is aware of which users are high-bit-rate users and also of the angular position of
35 each user in its cell area (from uplink parameters or mobile station location techniques) and of the base

station downlink transmission power level for each user. Based on this information, the base station is able to assess itself, for each mobile station, which users are likely to be the most significant interferers and then simply transmit the items of code information CI for the m most significant interferers to the mobile station concerned on the associated control channel ACCH (or some other dedicated control channel for the mobile station). In this case, the code identity derivation unit 52 described above with reference to Figure 1 can be used without modification.

In this case, the items of code information could be transmitted to a particular mobile station during (or just after) the setting up of a call by the mobile station and thereafter periodically to reflect the changing interference conditions within the cell.

Although as described above, the processing unit PU of the interfering signal processing section and the wanted signal processing section are both in the form of a RAKE receiver having plural fingers, it is not necessary to use such RAKE receivers for one or both sections. The RAKE receivers could be replaced by matched filters.

Although, as described above, significant interfering users are likely to be high bit-rate users, the present invention can be applied advantageously to reducing interference from any designated user whose spreading code can be identified to the mobile station.

Embodiments of the present invention are applicable to the following types of communication system:

- (1) UMTS frequency division duplex (FDD) mode (W-CDMA)
- (2) UMTS time division duplex (TDD) mode (both as proposed by the Association of Radio Industries and Businesses (ARIB) and as proposed by ETSI {TD-CDMA})
- (3) IS-95

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- (4) cdma2000
- (5) other DS CDMA systems

In all above cases the standard needs to incorporate the "BTS periodically broadcasting or informing the mobile stations of the short spreading code identity (and if necessary long scrambling code identity) of the interfering downlink channels". So IS-95 standard as it is cannot be utilised. It needs to be changed or upgraded. In principal most standards are upgraded for example: GSM by means of Phase1, Phase2, Phase 2Plus etc.

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CLAIMS

1. A mobile station, for use in a CDMA communications network, including:

5 wanted signal processing means for processing an input signal, representing a CDMA transmission signal received at the mobile station from a base station of the network, to derive therefrom a wanted signal embodying a preselected spreading code;

10 code information receiving means for receiving from the base station code information identifying a further spreading code assigned by the network to an interfering signal of another network user; and

15 interfering signal processing means for employing the further spreading code identified by the received code information to reduce the interference effect of that interfering signal on the derived wanted signal.

2. A mobile station as claimed in claim 1, wherein:

20 the said code information receiving means are operable to receive from the base station a plurality of items of code information corresponding respectively to a plurality of such interfering signals, each such item identifying a spreading code assigned by the network to its corresponding interfering signal; and

25 the said interfering signal processing means are operable to employ the spreading codes identified by the received items to reduce the interference effect on the derived wanted signal of each of the interfering signals of the said plurality.

30 3. A mobile station as claimed in claim 1 or 2, wherein the said input signal of the wanted signal processing means is pre-processed by the interfering signal processing means to reduce or cancel components in the input signal associated with the or each said interfering signal.

35 4. A mobile station as claimed in claim 3, wherein the said interfering signal processing means are

operable to derive, for the or each said interfering signal, a corresponding interference cancellation signal representative of a component in the said input signal associated with that interfering signal.

5 5. A mobile station as claimed in claim 4, wherein the said interfering signal processing means are operable to subtract the or each said interference cancellation signal from a signal representing the received CDMA transmission signal to produce the said
10 input signal of the wanted signal processing means.

6. A mobile station as claimed in claim 4 or 5, wherein the said interfering signal processing means are operable to derive the or each said corresponding interference cancellation signal from a signal
15 representing the said received CDMA transmission signal.

7. A mobile station as claimed in any one of claims 4 to 6, wherein the said interfering signal processing means has, for the or each said interfering signal, a
20 corresponding processing unit for deriving the said interference cancellation signal corresponding to that interfering signal, which processing unit includes:

code generator means for generating the identified spreading code assigned to the said interfering signal;

25 despreading means connected for receiving a first signal representing the received CDMA transmission signal and also connected to the said code generator for receiving the generated spreading code, and operable to despread that signal to produce a second
30 signal representing the said interfering signal; and

respreading means connected to the said despreading means for receiving therefrom said second signal and also connected to the said code generator means for receiving the generated spreading code, and
35 operable to respread the said second signal to produce the said corresponding interference cancellation

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signal.

8. A mobile station as claimed in any one of claims 4 to 7, wherein the said interfering signal processing means further include:

5 signal delay means connected for receiving a basic signal representing the said received CDMA transmission signal and operable to delay that basic signal by a preselected delay time to produce a delayed version thereof, the said input signal of the or each said
10 processing unit being provided directly by, or being derived from, the said basic signal; and

 subtraction means connected for receiving the said delayed version of the said basic signal and the or each said interference cancellation signal, and
15 operable to produce the said input signal of the said wanted signal processing means in dependence upon the difference between the said delayed version and the or each interference cancellation signal.

9. A mobile station as claimed in any preceding
20 claim, wherein one or both of the said wanted signal processing means and the said interfering signal processing means comprise(s) a RAKE receiver having a plurality of fingers for processing different respective paths of the received CDMA transmission
25 signal.

10. A mobile station as claimed in claim 9, wherein each of the said wanted signal processing means and the said interfering signal processing means comprises such a RAKE receiver, and the said mobile station further
30 comprises:

 path searcher means connected to the said wanted signal processing means and to the said interfering signal processing means for supplying the same path information thereto; and

35 path information delay means connected between the said path searcher means and the said wanted signal

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processing means for delaying supply of the path information to the wanted signal processing means for a preselected delay time after the same path information is supplied to the said interfering signal processing means.

11. A mobile station as claimed in any preceding claim, wherein the said code information receiving means are operable to receive the said code information via a common control channel broadcast by the base station to all mobile stations in its area.

12. A mobile station as claimed in any one of claims 1 to 10, wherein the said code information receiving means are operable to receive the said code information via a control channel associated individually with the mobile station.

13. A mobile station as claimed in any preceding claim, wherein the said base station is operable to form respective beams for directing its CDMA transmission signals towards their respective users and is also operable to transmit to the said mobile station interference judgement information providing, for each of a plurality of users operating in its area, information relevant to assessing an interference effect on the wanted signal of the said mobile station of an interfering signal of the user concerned;

the said mobile station comprising:

interfering signal assessment means for assessing the said interference effect of the interfering signal of each user of the said plurality based on the received interference judgement information; and

interfering signal selection means for selecting one or more of the interfering signals from amongst the respective interfering signals of the users of the said plurality based on the results of the assessment.

14. A mobile station as claimed in claim 13, wherein the said interference judgement information for such a

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user of the said plurality includes position information of that user.

15. A mobile station as claimed in claim 13 or 14, wherein the said interference judgement information for such a user of the said plurality includes angular position information of the user relative to the base station.

16. A mobile station as claimed in any one of claims 13 to 15, wherein the said interference judgement information for such a user of the said plurality includes downlink transmission power level information of that user.

17. A mobile station as claimed in any one of claims 13 to 16, wherein the said interfering signal assessment means take account of the position of each user of the said plurality relative to the position of the mobile station in assessing the said interference effect.

18. A mobile station as claimed in any one of claims 13 to 17, wherein the said interfering signal assessment means include storage means for storing the received interference judgement information for each user of the said plurality.

19. A mobile station as claimed in any one of claims 13 to 18, wherein the users of the said plurality are users whose downlink transmission rates exceed a predetermined threshold value.

20. A base station, for use in a CDMA communications network, including:

interfering signal designating means for designating at least one of a plurality of downlink signals transmitted by the base station as being an interfering signal having an interference effect on a wanted signal of a subject mobile station of the network; and

code information transmission means for including,

in a predetermined control signal transmitted by the base station to the said subject mobile station, code information, identifying a spreading code assigned by the network to the designated interfering signal, for use by the subject mobile station to reduce the said interference effect of the said interfering signal on its said wanted signal.

21. A base station as claimed in claim 20, wherein the said predetermined control signal is broadcast by the base station to all mobile stations in its area using a common control channel.

22. A base station as claimed in claim 20, wherein the said predetermined control signal is transmitted by the base station to the said subject mobile station using a control channel associated individually with that mobile station.

23. A base station as claimed in any one of claims 20 to 22, further comprising:

interfering signal assessment means for assessing, for each of a plurality of users operating in the area of the base station, the said interference effect on the said wanted signal of the said subject mobile station of the downlink signal of the user concerned;

the said interfering signal designation means being operable to determine which downlink signals of the users of the said plurality are to be designated as such interfering signals based on the results of the assessment.

24. A base station as claimed in claim 23, wherein the said interfering signal assessment means are operable to assess the said interference effect in dependence upon the bit rate of the downlink signal.

25. A base station as claimed in any one of claims 20 to 24, wherein the said base station further includes beamforming means for forming respective beams for directing its CDMA transmission signals towards their

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respective users.

26. A base station as claimed in claim 25, wherein the said interfering signal assessment means are operable to assess the said interfering effect in dependence upon a position of the user relative to the said subject mobile station.

27. A base station as claimed in claim 25 or 26, wherein the said interfering signal assessment means are operable to assess the said interference effect in dependence upon one or more of the following criteria:

an angular position of the user relative to the said base station;

an angular position of the said subject mobile station relative to the base station;

a distance of the user from the base station;

a distance of the subject mobile station from the base station;

a downlink transmission power level of the user; and

a downlink-signal bit-rate of the user.

28. A base station as claimed in claim 20, 21 or 22, further including:

beamforming means for forming respective beams for directing its CDMA transmission signals towards their respective users;

interference judgement information transmission means for including, in a predetermined control signal transmitted by the base station to the said subject mobile station, interference judgement information providing, for each of a plurality of users operating in the area of the base station, information relevant to assessing an interference effect on the said wanted signal of the downlink signal of the user concerned.

29. A base station as claimed in claim 28, wherein the said interference judgement information for such a user of the said plurality includes position information of

that user.

30. A base station as claimed in claim 28 or 29, wherein the said interference judgement information for such a user of the said plurality includes angular position information of the user relative to the base station.

31. A base station as claimed in any one of claims 28 to 30, wherein the said interference judgement information for such a user of the said plurality includes downlink transmission power level information of that user.

32. A CDMA communications network including:
a mobile station; and

a base station operable to designate at least one of a plurality of downlink signals transmitted thereby as being an interfering signal having an interference effect on a wanted signal of the said mobile station, and also operable to include, in a predetermined control signal transmitted thereby to the said mobile station, code information identifying a spreading code assigned by the network to the designated interfering signal;

the mobile station being operable to receive the said predetermined control signal and to employ the said spreading code identified by the code information included in that signal to reduce the said interference effect of that interfering signal on the said wanted signal.

33. A receiving method, for use in a mobile station of a CDMA communications network, including the steps of:
receiving a CDMA transmission signal from a base station of the network;

processing an input signal representing the received CDMA transmission signal to derive therefrom a wanted signal embodying a preselected spreading code;
receiving from the base station code information

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identifying a further spreading code assigned by the network to an interfering signal of another network user; and

employing the further spreading code identified by the received code information to reduce the interference effect of that interfering signal on the derived wanted signal.

34. A transmission method, for use in a base station of a CDMA communications network, including the steps of:

designating at least one of a plurality of downlink signals transmitted by the base station as being an interfering signal having an interference effect on a wanted signal of a subject mobile station of the network; and

including, in a predetermined control signal transmitted by the base station to the subject mobile station, code information, identifying a spreading code assigned by the network to the designated interfering signal, for use by the mobile station to reduce the said interference effect of the said interfering signal on its said wanted signal.

35. A CDMA communications method, including the steps of:

designating at least one of a plurality of downlink signals transmitted by a base station of the network as being an interfering signal having an interference effect on a wanted signal of a subject mobile station of the network;

including, in a predetermined control signal transmitted by the base station to the subject mobile station, code information identifying a spreading code assigned by the network to the designated interfering signal;

receiving the predetermined control signal at the mobile station and employing the spreading code

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identified by the code information included in that signal to reduce the interference effect on the wanted signal of that interfering signal.

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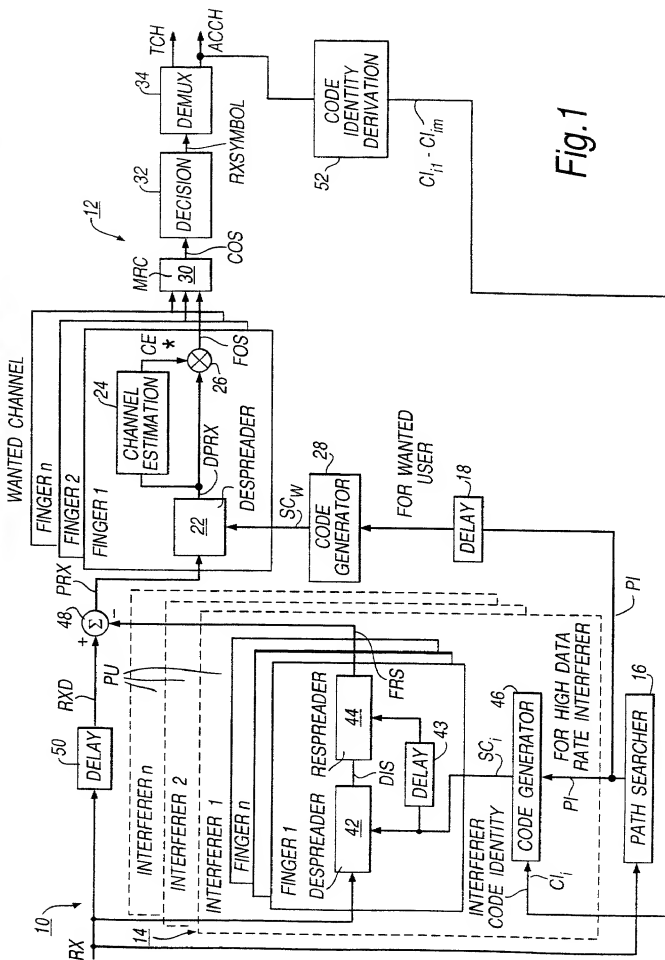


Fig. 1

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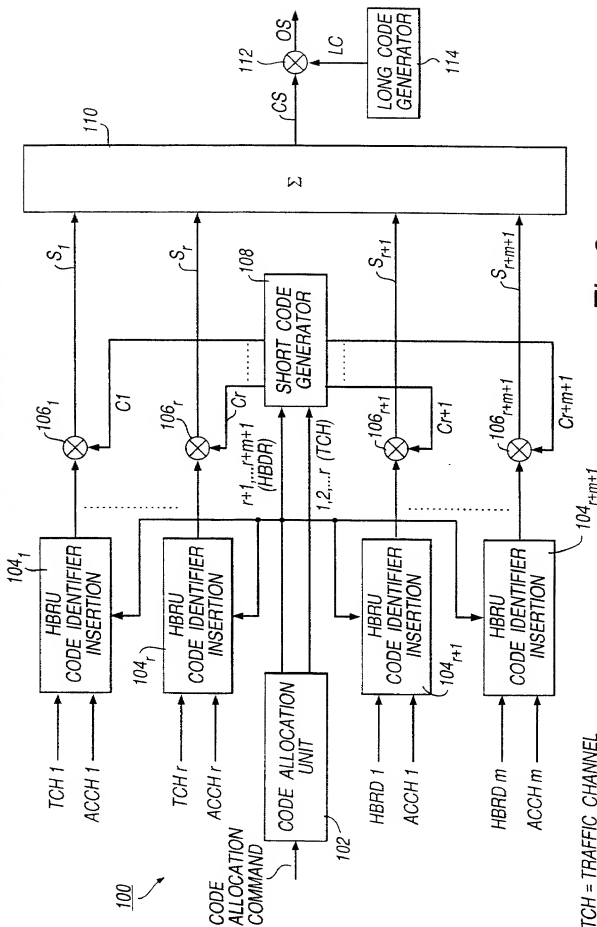


Fig. 2

TCH = TRAFFIC CHANNEL
 HBRD = HIGH BIT RATE DATA CHANNEL
 ACCH = ASSOCIATED CONTROL CHANNEL

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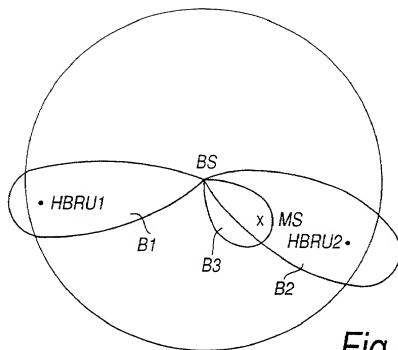


Fig.3

INT. NO.	SHORT CODE ID	ANGULAR POSITION	Tx POWER
1			
2			
3			
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x			

152

164

CBCH

INTERFERER
CONTROL
PORTION $CI_{i1} - CI_{im}$

162

Fig.5

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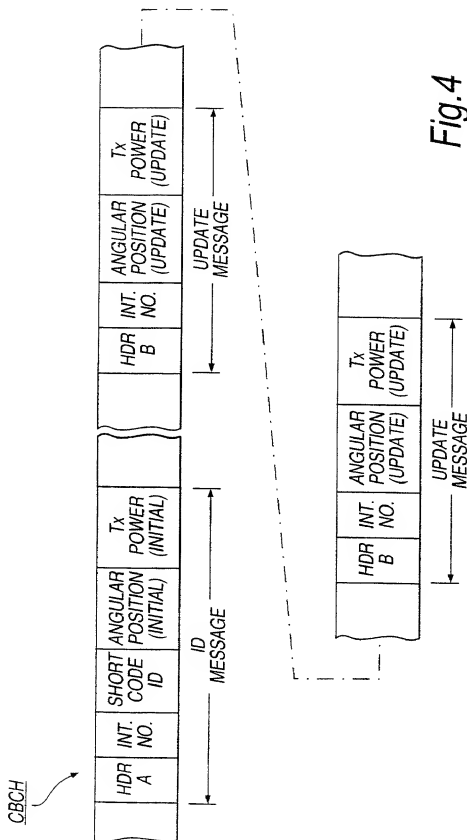


Fig.4

DECLARATION FOR PATENT APPLICATION

UNITED STATES

Docket No. FUJL 18.096

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: **"CODE-DIVISION MULTIPLE ACCESS MOBILE COMMUNICATIONS NETWORKS"**

the specification of which

(check one)

☒ is attached hereto☐ was filed on _____ as

Application Serial No. _____

and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by an amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

9820559.4

(Number)

UNITED KINGDOM

(Country)

21 September 1998

(Day/Month/Year Filed)

Priority Claimed

☒ Yes ☐ No_____
(Number)_____
(Country)_____
(Day/Month/Year Filed)Yes ☐ No ☐_____
(Number)_____
(Country)_____
(Day/Month/Year Filed)Yes ☐ No ☐

I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)_____
(Filing Date)_____
(Status-patented, pending, abandoned)_____
(Application Serial No.)_____
(Filing Date)_____
(Status-patented, pending, abandoned)

I hereby appoint as my attorney and agent Aaron B. Karas, Reg. No. 18,923; Samson Helfgott, Reg. No. 23,072; Leonard Cooper, Reg. No. 27,625; Emma Shleifer, Reg. No. 29,734; Linda S. Chan, Reg. No. 42,400; Harris A. Wolin, Reg. No. 39,432; Brian Myers Reg. No. P46247 and Jacqueline M. Steady, Reg. No. 44,354 to prosecute this application and to transmit all business in the Patent and Trademark Office connected therewith.

Address all correspondence to:

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New York, New York 10118-0110
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor

Sunil Keshavji VADGAMA

Inventor's Signature

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